Light and Lighting

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A Searchlight Symposium

This term conveniently describes the series of papers presented at the I.E.S. Meeting in London on April 15 (see pages 63-66), though in fact many things besides searchlights—photometry, visibility, etc.—are discussed.

To present a whole series of papers such as this, at one meeting, is a new venture for the I.E.S. The subject matter was necessarily presented in skeleton form. The complete text and illustrations will be eventually printed as a special booklet—a formidable effort in present circumstances—and in a limited edition, though efforts will be made to render these somewhat specialised data available to all those specially interested therein.

I.E.S. Dinners in Glasgow and Nottingham

The I.E.S. Glasgow Centre made history on March 20 when, for the first time, the annual dinner was arranged, the chairman, Mr. J. M. Henshaw, presiding. The president of the Society (Mr. J. S. Dow) had accepted the invitation of the Centre to be present. After his address (compressed on this occasion into half an hour) had been given, a pleasant programme of song, conjuring, and variety terminated the evening. Another social event, the annual dance of the Bath and Bristol Centre, was arranged to take place in Bath on the same date.

Previously, on March 4, when the annual dinner-dance of the Nottingham Centre took place, Mr. H. C. Weston deputised for the president. In replying to the toast of the Society, proposed by Mr. O. E. Dickinson, he commented on the recent rapid growth in membership, which had now reached 2,000. He caused some amusement by his description of the last Council meeting in London, which, owing to the fuel crisis, took place by the aid of two candles, one for the president and the other for the secretary.

A.P.L.E. Conference

It is announced that the 1947 Conference of the Association of Public Lighting Engineers will be held in Southport during September 15-19. Following the annual meeting on the opening day Mr. Thomas Wilkie will be installed as president. In the evening there will be a civic reception by the Mayor and Mayoress. Particulars of the various papers to be read will be announced in due course. Meantime it may be noted that a special session on September 17 is to be devoted to "Safety First on the Road," and that the Council is offering a prize of 25 guineas for the best paper on "Safety First on the Highway," with special reference to lighting. The author of the winning paper will be invited to present it at the morning session on September 17. Special arrangements are being made for demonstrations of various types of street lighting, both gas and electric, and a series of Class "A" and Class "B" roads is being allocated for this purpose.

Further particulars of the Convention may be obtained on application to the Secretary of the Association of Public Lighting Engineers, 68, Victoria-street, London, S.W.1.

"Common Stairs"

During a recent visit to Glasgow it was interesting to learn something of the development of public lighting in that city and of the extraordinarily difficult conditions by which public lighting engineers are confronted. At the present time very little in the way of new constructive design can be attempted. Engineers are usually only too grateful if they can fill gaps, or in some measure provide for new developments, by getting hold of any available standard material. No very radical departures within the city area can therefore be expected. It was interesting to learn, however, that plans for a display of fluorescent lighting in Buchanan-street, on similar lines to the experimental installations in London, had been developed and would have been put into effect but for the arrival of the "fuel crisis," which set a halt to such efforts. Examples of new development are to be found on the roads serving the numerous emergency housing centres which are springing up around Glasgow. It is impracticable to adopt a uniform plan for all such sites. The best that can be done is to light certain stretches with whatever pattern of lantern and post that is most readily obtainable, thus at least securing uniformity over a limited region. One peculiar feature in Glasgow (it is, apparently, confined to that city) is that the public authority has somehow become responsible for maintaining not only public lamps but also all lamps on "common stairs," i.e., staircases serving large blocks of flats, tenements, etc. The number of lamps thus used actually exceeds in number those in the streets of the city proper. Unfortunately, too, such lamps seem to be particularly vulnerable to the stone-throwing practice of hooligans, which is adding so greatly to the trials of public lighting engineers throughout the country, and many are the desperate expedients—shields of wire gauze and the like—devised to give at least partial protection against malicious damage.

The Chairman of the I.E.S. Birmingham Centre, Mr. R. Mackenzie (left) shaking hands with the President of the Society, Mr. J. S. Dow (right), on the occasion of their annual meeting on February 28th. The photograph was taken during the proceedings by Mr. Satchwell.

I.E.S. Annual Dinner

We give once more a final reminder of the **I.E.S. annual dinner,** which is to take place at Grosvenor House, Park-lane, London, on **May 14** (6 p.m.). **Evening dress is optional.**

Any members who wish to attend but who have not yet applied for tickets, are advised to do so at once. It will be recalled that initially, owing to limited accommodation, members were asked to limit themselves to one guest each. A considerable number of members have, however, already recorded their wish to bring additional guests and tickets can now be furnished in such cases on final application.

Forthcoming I.E.S. Meetings

(Provisional List)

SESSIONAL MEETINGS IN LONDON

1947.

May 13th. Annual General Meeting followed by an **Address** by DR. N. A. HALBERTSMA. (President of the International Commission on Illumination). (*At the Institution of Mechanical Engineers, Storey's Gate, London, S.W.*1) **6 p.m.**

May 14th. Annual Dinner. (*At the Grosvenor House, Park Lane, London, W.*1) **6.30** for **7 p.m.**

MEETINGS OF CENTRES AND GROUPS

1947.

May 2nd. Annual General Meeting followed by MR. L. C. RETTIG on **Drawing Office Lighting.** (*At Radiant House, Bristol.*) **7 p.m.**

May 2nd. The Physics of Light. (*At Gloucester.*)

May 8th. Annual General Meeting followed by MR. P. J. WATSON on **Modern Church Lighting.** (*To be held at Swansea.*)

May 9th. MR. H. J. CULL on **The Physical Nature of Light.** (*At the Imperial Hotel, Temple Street, Birmingham.*) **6 p.m.**

May 17th. Annual General Meeting and Luncheon. (*Leicester.*)

(Secretaries of Centres and Groups are requested to send in particulars of any changes in programme, mentioning subject, author, place, date and time of meeting; summaries of proceedings at meetings (which should not exceed about 250–500 words) and any other local news are also welcome.)

Illuminating Engineering Course in Glasgow

Whilst occasional lectures on special aspects of lighting usually meet with a good response, the organisation of regular courses on illuminating engineering at colleges and institutions has hitherto proved very difficult. All the more honour, therefore, to Glasgow, where, at the Stow College, a course has been running with success for the second year in succession. This course has resulted in a substantial number of entries for examination in illumination conducted annually by the City and Guilds of London Institute. One essential to success is to find an inspiring lecturer, and undoubtedly the personality of Mr. F. M. Hale and his enthusiasm has had a great deal to do with the good results in this instance. One learns with regret that Mr. Hale fell a victim to the recent bitter weather in Scotland, slipping and spraining both knee and ankle. We hope that he will soon make a good recovery, but in the meantime he has done all possible to meet the needs of his students by correspondence.

E.L.M.A. 48th Illumination Design Course

The above course, announced to take place at the Lighting Service Bureau during May 6-9, was originally intended for March, but was postponed owing to the electricity cuts. We gather that this is in the nature of an "overflow" course, to which those who were crowded out on previous occasions may still gain entrance on application to the Lighting Service Bureau at 2, Savoy-hill, London, W.C.2.

Symposium on Searchlights

In what follows a summary of a special series of papers read before the Illuminating Engineering Society in London on April 15th.

A new departure was made on the occasion of the meeting of the Illuminating Engineering Society on April 15 last when for the first time a series of papers on allied subjects was presented. In what follows a summary is given of the five papers, but the full version of the complete series, including additional written contributions, will be published in book form in the same manner as with the Convention Papers which are now in course of completion.

(1) The Function and Design of Army Searchlights, *by Mr. E. W. Chivers and Mr. D. E. H. Jones.*

Searchlights as military weapons have been known and used for many years, but new interest in their application was kindled by the development of aerial warfare during the 1914-18 war. The performance required from the searchlight now necessitated more accurate design both in the optics of lamp and reflector and also in the mounting, and the problem attracted the attention of a number of scientists and engineers. As in all design, however, the final result must be a compromise between the users' requirements, the scientific ideal, and the economic and practical possibility.

Beam characteristics are determined by the reflector and source combination, divergence being determined by the focal length of the reflector and the source size whilst the intensity of the beam depends upon the aperture of the reflector, the brightness of the source, and the efficiency of the complete apparatus. As neither a perfect reflector nor a small uniformly bright source is available variations in these two components have an appreciable effect in increasing the beam divergence and in decreasing the beam intensity. A method of testing reflectors for imperfections and their effect on beam divergence is described. Some full-scale field tests for comparing the visual range of various sizes of searchlights under specified conditions both for a static target method and for an aircraft target method are described in the paper.

The source used in all Service searchlights is the positive crater of the carbon arc and its development has resulted in higher source brightness and smaller source size. The current density in the positive carbon has been progressively increased and higher luminous efficiencies have resulted. The positive carbon consists of an outer shell of relatively hard carbon and an inner core of about 8 mm. diameter. The material of the core is a mixture of carbon and certain rare earth salts (e.g., cerium salts) and is so chosen that it volatilizes more readily than the shell material. At current densities greater than 0.5 amp./sq. mm. a deep crater is found in the positive carbon, the crater being filled with a vapour ball formed of a mixture of the volatilized rare earth salts and carbon. This ball, raised to incandescence at the high temperature of the arc, forms the source of light of the arc. The mechanism used for holding and feeding the carbons, usually termed the lamp, has shown parallel development.

The 150 cm. anti-aircraft searchlight is described as an example of the stage now reached in a particular application. The various methods of searchlight control used by the Army are detailed and finally the main types of searchlights in service are briefly described.

(2) High Power Searchlights Capable of Wide Divergence, *by Air Commodore W. Helmore, Dr. H. K. Cameron, Dr. F. S. Hawkins, Mr. L. B. W. Jolley, and Mr. L. M. King-Brewster.*

The development of a searchlight carried by a fast fighter aircraft and

used for illuminating enemy bombers is described in the first part of the paper. It is shown that the operational requirements could be met by the employment of a beam of elliptical cross-section having a horizontal divergence of 30°, and a vertical divergence of 7°, but it was found that the required flux intensity could only be obtained by the use of a high current density carbon arc larger in size than any of this type previously known. The development and photometry of an arc lamp burning 37 mm. positive carbons at 1,400 amperes, 140 kW., is described and an account is given of the unexpected changes in the nature of the arc at these currents. Details are also given of the effect of reduction of atmospheric pressure, such as would be experienced at altitude, on the character and light output of the arcs employed. For example, at 20,000 ft. there is a decrease in peak candle power of the order of 10-25 per cent. and a decrease in efficiency of about 15 per cent. though on the other hand stability of arc is greatly increased. Finally there is a brief description of the installation of the projector and its secondary battery power supply in aircraft.

The second part of the paper covers the development of a ground searchlight of high power. The requirements of a divergence of about 6° was met by an arc burning a 64 mm. positive carbon at 4,000 amperes, 600 kW., in a projector having a parabolic reflector 156 cm. in diameter. Brief details are given of the water-cooled arc lamp and projector used and preliminary experiments with a projector fitted with a parabolic mirror 300 cm. in diameter are described. The results of photometric measurements are given in each case, a peak beam intensity of 2,700 megacandles being achieved with the 300 cm. mirror. Finally, an analysis is given of the optical effects of defocusing the source in these projectors, for it was an operational requirement that the divergence of the beam from these projectors should be increased or decreased at will.

(3) Photometry of Searchlights, *by Dr. H. K. Cameron, Dr. E. H. Rayner, Mr. E. R. Thomas, and Mr. G. T. Winch.*

The photometric appraisal of searchlight projectors has long been regarded as an essential factor in their development. The work described in this paper was undertaken more particularly as an aid to assessing the performance of carbon electrodes made for searchlight projector arc lamps. With the advent of war an intensive study of light sources suitable for use in searchlights became necessary, and this required an extension of the existing photometric methods in order to speed up the rate at which the photometric characteristics of the lamp and searchlight beam could be measured. Under the stimulus of black-out restrictions new telephotometric methods were developed which enabled all outdoor beam measurements to be made in daylight. To assess a light source completely requires a knowledge of its size and brightness distribution, the form and perfection of the mirror (or optical system), and the resulting intensity distribution of the searchlight beam.

The paper describes new methods and apparatus which have been devised in order to facilitate the measurement, appraisal, and correlation of sources, optical systems and beam performance of searchlights. Any attempt to correlate direct tests on the source with performance in the projector involves some consideration of the optical system, which for most searchlight purposes is a mirror of paraboloid form. The minimum size of source required to flash the mirror completely depends upon the small departures from paraboloidal form, and, where glass mirrors are concerned, the glass thickness. As the brightness of a carbon arc source is far from uniform, some consideration of mirror imperfections in relation to the brightness distribution of the source was necessary, and experimental methods which have been developed for this purpose are described.

Various developments in photometric and telephotometric apparatus suitable for making beam intensity measurements by daylight are described, and typical distribution curves obtained by these means are given, including a method for correlating the characteristics of the light source and optical system, and an example is given showing close agreement between estimated and measured

beam performance. Measurements of beam intensity distribution made over photometric ranges of 1,500 and 5,000 feet confirm theoretical calculations that, provided the projector is focused for optimum flash, no significant differences in beam intensity or distribution are observed.

(4) The Visibility of Targets in a Naval Searchlight Beam, *by Mr. W. D. Chesterman and Dr. W. S. Stiles.*

Suppose that under prescribed atmospheric conditions a particular target is at a given position in the beam of a searchlight. Will this target be visible to an observer stationed at an assigned point near the projector? The investigations described in this paper were made to find the answer to this question when the several variables—the size and other characteristics of the target, the clarity of the atmosphere, the intensity and divergence of the beam, etc.—have the values appropriate to naval applications. It was impracticable to make full-scale trials the main basis of the work because of the many cases to be considered, and because of the technical difficulty of such trials, particularly under wartime conditions. In the method adopted calculations were made of the brightnesses of beam and target as seen by the observer for the various practical situations to be considered. This having been done, a quantitatively correct simulation of the picture presented by beam and target was projected on a screen in the laboratory, and by observations on this simulation it was determined whether the target was or was not visible for different target sizes, beam brightnesses, etc. Finally, these laboratory data on visibility were used in conjunction with the calculated beam and target brightnesses, to derive the limiting range of certain targets, and to find how limiting range depends on all the relevant factors—beam and observer properties, atmospheric properties, and target properties.

The term "range" is used in several papers in this symposium on searchlight problems, and the authors of this paper emphasise that a searchlight does not possess a definite maximum range in the same sense as a gun. The meaning to be attached to the word "range" needs to be specified with some precision, and the actual values for the range obtained on any useful specification will depend on a whole group of practical variables. For certain combinations of these variables high ranges are obtained, but it is not a useful procedure to try to select the greatest range obtainable under the most favourable conditions, as there is a danger of such a maximum range being regarded as a figure of merit for the searchlight.

The paper deals first with the laboratory investigations, followed by a brief account of the calculation of beam and target brightnesses and limiting ranges. Finally the general conclusions from the investigation are summarised.

(5) Some Visibility Problems Associated with Anti-Aircraft Searchlight Beams, *by Mr. S. S. Beggs and Mr. J. M. Waldram.*

Visibility problems associated with anti-aircraft searchlights differ from those with naval searchlights in several particulars. The most important is the scatter of the atmosphere, which varies greatly with altitude both in amount and distribution and which cannot be regarded as constant along the length of the beam. The problem is also geometrically different, being three-dimensional, and the significance of range differs from that in the naval case. All these considerations led to different approaches to the two problems, and the additional variables in the aircraft case made it impossible to state some results in terms of range, as has been done in the naval case.

It is obvious that a target in the beam of a searchlight in a turbid atmosphere will be most easily visible if the divergence is only just sufficient to cover the target, so that the illumination of the atmosphere is a minimum. Such a specification, however, is impracticable, as there is no point in providing a light which would reveal targets excellently but could rarely get on to them. The gunners would rather see less well but more often. The beam must have a divergence sufficient to allow engagement and following of the target with the equipment and the skills available, and some compromise must therefore be reached between conflicting requirements. The reaching of that

compromise is a matter for operational research, depending upon tactical as well as technical considerations, and more than one solution may be possible: but if it is to be reached intelligently the effects must be known of the many variables upon the performance of the searchlight as an aid to vision.

The paper describes investigations of three specific problems, namely, the visibility of aircraft targets in a beam (1) seen from the ground near the searchlight, (2) seen from a fighter aircraft at nearly the altitude of the target, and (3) the visibility from the air of the beam itself as a pointer. Three searchlights of different sizes have been investigated, taking the data as measured for three actual atmospheres, which showed changes in both amount and type of scatter with altitude. The controlling factor in all three problems is the atmosphere; in the first problem particularly it may bring about unexpected effects with a black target, which are not important in the case of the naval searchlight. The effects of changes in the characteristics of the searchlight are examined and the relative performances of the three types investigated are discussed, so far as concerns the above three questions.

The British Standards Institution

A recently issued leaflet ("British Standardisation and Industrial Progress") recalls the origin of the British Standards Institution which came into being in 1901 as a result of the difficulties arising from the large range of types and dimensions existing in the iron and steel industry. Standardisation in this field achieved a great improvement and the same procedure was subsequently adopted throughout the engineering industries. Ultimately the charter of the British Engineering Standards Association, as it was then known, was revised to cover the whole of productive industry. Under its present name the institution now covers four main groups of industries: engineering, chemical, building, and textiles, besides interesting itself in innumerable other special problems. There are 50 separate "industry committees" and in all there are no fewer than 11,000 committee members, all voluntary, and at least 1,500 meetings and conferences are held each year. In the specific field of industry that interests us—lighting—the B.S.I. has done excellent work. A statement by Lord Woolton, president of the institution, contains a reminder of the value and extent of this work, which is still expanding. We hope that the appeal which he commends to manufacturers for generous contributions to the institution's funds will find a ready response.

Careers in the Gas Industry

Young people, in choosing their vocation, are always under the great handicap of knowing so little of the various industries which they are invited to enter. The Institution of Gas Engineers has done a good service, therefore, by the issue of the illustrated pamphlet bearing the above title. In this it is explained how gas is made, distributed, and applied, and what are the various jobs awaiting those who enter the gas industry. In the opening chapter the gas industry as a pathway to opportunity is reviewed. Subsequently the question "What is an Industrial Career" is answered and the reader learns somethings of the work of the scientist, the engineer, and the commercial expert in this special field. Other chapters deal with the work of contracting firms and makers of gas apparatus, technical education in the gas industry, and opportunities for women. The pamphlet is brightly written and excellently produced. Those interested and desiring copies should communicate with the Secretary of the Institution of Gas Engineers, 1, Grosvenor-place, London, S.W.1.

Mr. B. C. Ossitt, an I.E.S. member and a member of the committee of the Leeds Centre, has been appointed Street Lighting Superintendent to the Borough of Nuneaton and entered upon his duties early in the past month. I.E.S. members will join us in offering to Mr. Ossitt congratulations on his appointment and best wishes for success therein.

What Is Visibility?

An Interesting Court Case

By LESLIE T. MINCHIN,
B.Sc., M.Inst.Gas E., F.I.E.S.

The technique of seeing must be a vital factor in many court cases, although a proper appreciation of the scientific aspect is less often found. The following notes on a recent manslaughter trial which the author attended may be of interest to illuminating engineers, since the case so largely hinged on matters of lighting technique.

The scene of the accident was a 40 ft. road, newly surfaced, running along the coast to a small town. The road followed the shoreline of the bay in a gentle curve, and at this point began to swing inland slightly. The street lighting installation consisted of 3-lt. gas lamps in square lanterns fitted with directional reflectors set to give a maximum C.P. of about 300 at somewhere near the horizontal: they were only 12 ft. 6 in. high, 350 ft. apart and mounted on the landward side only. Thus they were on the outside of the bend for most of the road's length, but on the inside at this particular spot. A rather young and inexperienced motorist was driving a private car towards the town along the coastal road at about half an hour after lighting-up time on a clear evening. Three cyclists in a group going in the same direction were passed, the car's speed being then about 38 m.p.h. Beyond the cyclists the motorist swerved back into the near side of the road again and ran down a man who was cycling home from work some 70 ft. in front of the cyclists just mentioned.

The evidence on which the prosecution was based was, at first sight, formidable. The cyclists behind testified that the victim was clearly visible to them, both by his outline and by his rear light, which was in good order. Witnesses also stated that it was not yet dark, that features in the park adjoining the road on the landward side were easily discernible, that headlamps were not necessary, because it was "not yet really dark." The street lamps were in good order and all were in lighting at the time. If under such conditions the defendant had knocked the cyclist down, it was argued, the only possible explanation was such a criminal disregard of human life as to justify a charge of "manslaughter."

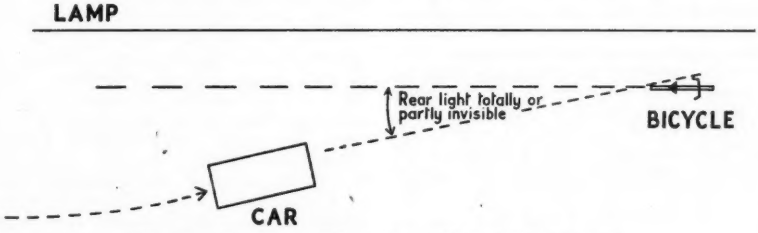

Diagram showing position of car 45 ft. behind bicycle.

Counsel for the defence, who ultimately obtained an acquittal, based his argument on the following lines. A road lit by lamps on short columns 350 feet apart is most deceptive and misleading to an inexperienced driver. It is an installation which is well below the standards laid down both in the old B.S.I. Specification and the M.O.T. Report of 1937. Between the patches of light produced on the road are very considerable areas of blackness in which objects can easily be hidden. Units of this type, mounted as low as this, and with such a very dark background (there were no buildings on either side) were definitely glaring, and reduced the

perceptibility of an object quite markedly. It was noteworthy that the fatal collision took place just beyond a lamp, at the point in the road which usually is darkest. Glare was also produced by cars coming in the opposite direction, and since on the seaward side there were no street lamps at all, nearly every car coming towards the driver used headlights. At this particular spot the effect was accentuated by a very slight double curve which brought the lamps of oncoming cars directly into the driver's field of vision. All these factors made seeing on the road very difficult, but still did not explain why the driver did not see the rear light of the cyclist. Here, however, another factor entered the case, for it transpired that the victim's rear lamp was mounted on the inner or near side of the back wheel and some 5 in. below the top of the rear mudguard. Some rough experiments were therefore made with a similar cycle having similar lamps. The observer crouched to bring his eyes to the level of the car driver's—in this case 4 ft. 2 in.—and measured the distance off the track-line of the cycle at which the light was obscured. At a distance of 30 ft. the light was completely hidden 6 ft. off the track-line: at 45 ft. the corresponding figure was 8 ft.

This being so, the motorist approaching from the crown of the road might quite possibly not have seen the rear light at all: and therefore was disposed to swing towards the side of the road where there appeared to be a clear passage.

How then could this happen at a time of the evening when, according to the evidence of cyclists and pedestrians, it was still quite light? Inspection of the road at a comparable time of evening showed that the two facts are in fact compatible. The cyclist has no windscreen to look through, and he has been able gradually to adapt himself to the declining light. Moreover, the cyclist's attention is centred on the near kerb and road some 15 ft. to 20 ft. ahead of him, whereas the motorist has to look 100 ft. ahead into the dark centre portion of the road where he is much more liable to be dazzled by approaching headlamps. The visual tasks required of the two persons are so different that it is quite possible for one to describe the light as "quite good" and the other to find it dark and needing headlamps.

Very few accidents are wholly attributable to bad lighting, and this was certainly not one of them. Some lack of care is usually an ingredient: armed with a full measure of experience and road-wisdom the driver can usually survive the most unfavourable lighting conditions safely. In the case here described, however, the visibility factors probably made all the difference between a lack of adequate care and that degree of gross carelessness which would justify a charge of manslaughter: and it is evident that great injustice would have been done had they not been taken into account at the trial.

Fluorescent Lighting in a Tailoring Shop

In the tailoring and showroom premises of Messrs. Gieves Ltd. (Old Bond-street, London), the famous Naval, Air Force, and civilian outfitters, fluorescent lighting with 80W. Sieray lamps has recently been installed. In the tailoring section (illustrated) and offices "daylight" lamps are used. The lighting was planned and supervised by their architect, Mr. Harold Cox, in conjunction with Siemens Electric Lamps and Supplies, Ltd., and the installation was carried out by Messrs. Rashleigh Phipps and Co.

International Conference on Optics, 1946

In Paris last October there was a reunion of workers in optics from all over the world, including a number from this country. The reunion was organised by the Institut d'Optique, whose director, M. Fleury, will be remembered by many delegates to meetings of the International Commission on Illumination.

A very large number of papers (over 140) were read at the sessions in Paris, and at a meeting of the Optical Group of the Physical Society on February 14 some of the British visitors to the reunion gave accounts of different sections of the subject which were covered. The first speaker was Mr. L. V. Chilton, who mentioned the visits paid to different institutions and said that he had been greatly impressed with the large amount of specialised equipment to be found in French laboratories. One interesting exhibit which he showed at the meeting was an example of stereoscopic photography. This depended on the interlacing of very narrow vertical strips of the two pictures normally used in stereoscopy. When this composite picture was viewed through a fine vertical grid placed at the correct distance in front of it a perfect stereoscopic effect was produced within a certain horizontal range of viewing angle. The principle is, of course, not new. It was proposed years ago for stereoscopic cinematography, but most members of the audience had not before seen an actual picture. It is understood that the system is to be developed commercially both in France and in this country.

The next speaker was Dr. H. H. Hopkins, who gave a brief account of the papers and discussions on the subjects of geometrical optics and instrument design. He mentioned specially M. Maréchal's work on the effect of the position of the effective stop on the aberrations in an optical system.

Mr. J. S. Preston then gave an account of that part of the proceedings which was devoted to photometry and allied subjects. He described the special type of emission photocell designed by M. Boutry with the object of securing the highest possible degree of proportionality between illumination and photocurrent. He also mentioned work on photoelectric spectrophotometry, on the colour temperature of stars and on the measurement of atmospheric transmission. He went on to say that Dr. H. König of Berne had given a useful paper on his method of heterochromatic photometry based on the use of a thermopile and eight colour filters transmitting in different parts of the spectrum.

Mr. Preston said that he had taken the opportunity to visit the Bureau International des Poids et Mesures at Sèvres and to see the equipment set up there for the photometric comparison of standard lamps received from the various national laboratories. He was much impressed with the elaborate precautions which had been taken to secure the highest possible accuracy in the work. The use of rectifier photocells was made possible by the fact that the lamps were all at the same colour temperature.

Dr. Hopkins had already mentioned that the conference lasted for two weeks; the papers were read during the first week and the second week was devoted to a series of less formal colloquies which were only attended by those directly and specially interested in the subjects discussed. It was during this second week that a proposal was put forward to establish a permanent International Commission on Optics, and it is understood that steps have been taken subsequently to give effect to this suggestion.

After a short interval, Dr. W. S. Stiles gave the meeting an account of that section of the conference dealing with physiological optics and allied subjects. At the Institut d'Optique, this branch of the work was directed by M. Arnulf and it was interesting to see how much the work of the Institut had proceeded on similar lines to that carried out in this country. For example, a study had been made in both countries of the threshold of visibility of light patches of different sizes and brightnesses. The fact that vision at night was improved by the addition of 1 or 2 dioptres of negative correction had also been studied and an explanation found in the chromatic and spherical aberrations of the eye combined with the shift in the visibility curve under dark adaptation. Other

work had been concerned with a reversal of the Stiles-Crawford effect at low brightnesses and with the relation between brightness and pupil diameter.

New work carried out during the occupation period included a study of methods of measuring the performance of optical instruments and a fundamental re-examination by M. Blottiau of the basic principles of photometric measurement. Rejecting the additivity law, M. Blottiau had proposed a kind of visual acuity photometer, but although this might theoretically get over the fundamental difficulty, in practice it was open to many objections and sources of uncertainty.

Other papers mentioned by Dr. Stiles were one on definitions and nomenclature and another on a method of colorimetry based on the analysis of the sensation rather than the stimulus. Work on the number of quanta of light energy needed to evoke the sensation of vision had been described by de Vries, while another author had given an account of an investigation of the dazzle caused to the pilots of landing aircraft by landing beacons. Finally, Dr. Stiles mentioned papers by Dr. W. D. Wright on the colorimetry of small test fields and by Dr. H. König on the axioms of heterochromatic photometry.

The various papers presented and discussed at the conference have not yet been published and no announcement has so far been made as to the time or mode of publication. It is to be hoped that the papers, at least, will be made generally available in the not too distant future, possibly in the form of a special volume or volumes of the "Revue d'Optique," in which most of the papers by members of the staff of the Institut d'Optique usually appear.

The proposal to form an International Commission on Optics is an interesting one. It will naturally have many points of contact with the International Commission on Illumination and some care may be necessary to avoid overlapping, on the one hand, or a divergence of practice (e.g., in nomenclature) on the other. In particular, the subject of physiological optics will naturally interest the membership of both bodies, and the same is true of colorimetry, which has so far come entirely within the sphere of action of the Illumination Commission. Doubtless these points have not escaped the notice of those concerned with the organisation of the new Commission and effective liaison should not be difficult to secure, not only at the international level, but also between the respective national constituent bodies.

B T H Stand at Ideal Home Exhibition

The accompanying picture illustrates the "Mazda Rest Room," which formed part of the interior of the B T H stand at the Ideal Home Exhibition. The familiar "Mazda Girl" will be noted in the background.

The Reds and the Greens

(or, Coloured Light the Rebel Against Order in Photometry)

By JOHN W. T. WALSH, M.A. D.Sc.

(This article first appeared in "Light and Lighting," October, 1940, and is now repeated in response to numerous requests.)

"What is truth?" said jesting Pilate, and would not stay for an answer
—Bacon.

"Seeing is believing," said the Plain Man one night to his friend Perkin G. Smith, as they were walking home after a late spell of duty.

"Oh, is it?" replied Smith. "I'm not so sure. Haven't you noticed that when those green traffic lights are on, the pavement here looks quite bright and you can read your watch without any difficulty, but as soon as they change to red the whole place seems to go dark?"

"Yes, I certainly have, and it seems to me a very stupid arrangement not to have them more nearly equal."

"But they *are* equal," cried Smith. "Look at the lights themselves. You can see at once that the clear crosses are the same size and about equally bright, and I happen to know that they *are*, roughly, the same."

"Well, then, how do you account for the difference on the pavement?" queried the Plain Man, and his only answer was a subdued rendering of a familiar air which recalled to his mind the words of Buttercup's cryptic warning to the Captain of H.M.S. Pinafore.*

"That's all very well," commented the Plain Man, rather crossly, "but either two things are equal or they are not, and I can see very well that the brightness of this pavement under the green light is *not* the same as its brightness when the lights are red so it's no use your telling me that it is."

"But I certainly never said anything of the sort," protested Smith. "What I said was that the lights themselves were equal; but I quite agree with you that the effects they produce as regards the brightness of the pavement are most unequal."

"Well, it's all very puzzling to a Plain Man, I must say."

"Yes, I suppose so; but after all that is only because we are so used to dealing with things we can weigh in a balance or measure with a tape. If we take a ton of sugar and a ton of sand and then divide each ton into 2,240 equal parts, we know that one part of the sugar will weigh the same as one part of the sand. But when it comes to illuminating a surface with lights of different colours matters aren't so simple by any means, because the eye doesn't treat the different colours with the same fine impartiality that our balance displays to everything that is weighed on it. The eye acts, in fact, as though it becomes more and more partial to greens and blues (or, if you like, more and more blind to reds and ambers) as the brightness gets less and less."

"Well, that's a new one on me," commented the Plain Man, "and I had no idea our eyes behaved in that ridiculous fashion."

"No more ridiculous than the Chancellor of the Exchequer, my dear Plain Man," said Smith, with apparently sublime irrelevance.

"The Chancellor of the Exchequer! Why, what on earth has he to do with it?"

"Oh, nothing, really, only it just occurred to me that we might all be very much upset if his idea of an equal sacrifice for all was an equal fraction of everyone's income. You see, our whole difficulty arises from the fact that we unconsciously tend to assume that the ordinary processes of addition and multiplication must apply to everything, whereas a moment's reflection would show us that they don't. However, perhaps we are straying from the subject, and, anyway, this is where I say 'goodnight.'"

* * *

Next week the two friends met again at the Post, and at the first opportunity Mr. Smith fished out of his pocket some postage stamps which he had brought to show his friend the P.M.

"You remember," said he, "our chat

*Things are seldom what they seem,
Skim-milk masquerades as cream,
Highlows pass as patent leathers;
Jackdaws strut in peacock's feathers.
Very true; so they do.

last week on the subject of the red and green traffic lights? Well, here are a couple of foreign stamps that may interest you. They were issued in 1937 by Czechoslovakia to commemorate the jubilee of a Johnnie named Purkinje. He carried out a lot of experiments on vision and was the first to notice—or, at any rate, to draw attention to—the curious effect we were discussing about the red and green traffic lights.

"As a matter of fact, I saw rather a neat demonstration of it the other evening at a meeting of a society I belong to: I wish you had been there. The chappie who was talking—a fellow named Preston, I think—had two large flat boards painted with some of this stuff that glows under what they call 'invisible light.' One board was red and the other was a bluish green. He started off with the lamp giving the invisible light right at the back of the hall, so that neither board gave enough glow for it to be seen. Then, as he brought the lamp up the centre gangway towards the platform, the blue-green board started to show up long before the red. In fact, it was getting quite strong by the time the red had just begun to glow. Then, as the lamp was brought still nearer and nearer to the boards, the red began to catch up with the blue until, finally, you couldn't say for certain which was brighter."

The Plain Man looked at the stamps for a few moments.

"So old What's-his-name noticed that effect half a century ago," said he, "yet I don't suppose there's one person in a thousand to-day who knows any more about it than I did, or who has even so much as heard of him. However, the Czechs seem to be proud of the old man, and it was a bright thought of theirs to make one of the stamps red and the other green, wasn't it? By the way, my acquaintance with the Czech language is strictly limited, and the spelling on the stamp doesn't help me much. How do you pronounce his name?"

"Well, most Englishmen call him Perkin G. (not that he's any relation of mine), but that's not correct, really. About the nearest we can get to it is Perkin-ye, but as he wrote for a scientific periodical published in German, the Czech spelling was changed to Purkinje, which gives about the correct sound in German. Then the German spelling got into the English literature on the subject, and so the name was anglicised with a fine disregard of its original form."

The Plain Man's attention was clearly wandering by the time his friend had come to the end of this rather involved explanation, and there the subject dropped.

* * *

I must confess to a good deal of sympathy with our friend the Plain Man. Certainly, it is most puzzling to those of us who are used to dealing with things capable of being measured by ordinary mechanical means to be brought suddenly up against a case where although A and B look equal, yet $\frac{A}{100}$ certainly does not look equal to $\frac{B}{100}$. We might, indeed, be tempted to dismiss photometry as an inexact science, or, perhaps, not a science at all, but this would be a mistake. In fact, so long as the brightness of the surfaces we compare is high enough the trouble does not arise. For instance, if the brightness is not less than that of white paper under an illumination of 1 ft.c* there is no difficulty, and the ordinary rules of addition and multiplication can be applied.

Of course, the comparison of a red surface with a green one is always rather an unsatisfactory process, and colour difference has remained the bugbear of photometry ever since the pioneering days of Bouguer and Lambert. As Bouguer rightly remarked in 1760: "La comparaison de deux lumières de différents couleurs est . . . embarrassante" ("Traité d'Optique," p. 50); and Lambert, too ("Photometria," §309), laments: "Aegre comparantur claritates, quae colore plus minusve differunt." Nevertheless, while different observers differ, sometimes quite widely, in their judgments, there is, on the whole, sufficient consistency to justify the universal adoption (as a working convention) of a table or a curve giving the relative values assigned

* It has, alas, become increasingly popular to use as the unit of brightness the *equivalent foot-candle*, which is defined as the brightness of a white diffusing surface of 100 per cent. reflection factor when its illumination is 1 ft.c. No one has been able to explain satisfactorily in what way the brightness is "equivalent." The term has apparently followed the example of Topsy, and, to the grief of many, it has gate-crashed into the literature, all protests and counter-suggestions notwithstanding.

by the "average" human eye to equal amounts of energy at all parts of the visible spectrum. The essence of this convention is the fact that these relative values "stay put" when the intensities are altered, so that if, for instance, a certain red surface is found by the "average eye" to have a brightness equal to that of a certain green surface when the illumination of both is the same, the equality of brightness is not destroyed by any change in the value of this common illumination. Down to the limit of brightness mentioned earlier (1 eq. ft.c.) this essential condition is fulfilled quite satisfactorily, and even below it (e.g., at 0.1 eq. ft.c.) the departure is not easy to detect. It is only when we get down into the regions of brightness, or rather dimness, which have now become so common, that we find ourselves in difficulties.

This accounts for the unfortunate fact that there was until quite recently no agreement as to the way in which low brightnesses should be measured. Every photometrist knew quite well that the problem existed, but as it didn't come into his everyday work he was content to ignore it as probably of no more than academic interest. He was quickly shaken out of his complacency when a committee of the Illuminating Engineering Society and the British Standards Institution began to draw up a specification for the performance of phosphorescent and fluorescent materials.

These materials are of many different colours, and under normal conditions of use a brightness of 0.001 eq. ft.c., or even 0.0001 eq. ft.c., may well be of value. In the absence of any marked colour such a brightness is most easily measured by means of an ordinary portable photometer provided with a special neutral filter of low transmission, say one-hundredth or one-thousandth. The photometer is sighted at the surface to be measured, and the reading at the point of balance is first converted from illumination in foot-candles to brightness in eq. ft.c.*, and the result is then multiplied by the transmission factor of the filter, which is, of course, inserted so as to reduce the illumination of the comparison surface inside the instrument.

In the case of most phosphorescent or fluorescent materials the surface to be measured is not white but coloured, and then the temptation is to insert a colour filter in the instrument so as to obtain a colour match, the readings being, of course, multiplied by the transmission factor of the colour filter for white light. Assuming that this transmission factor has been determined in the usual way, viz., by means of measurements made at ordinary brightness levels, it will be found that the results obtained are very disconcerting. Not only do they fail to agree with measurements made when the observer does his best to obtain a brightness match without a colour filter (ignoring the colour difference as far as possible), but, what is far worse, in many cases they contradict the verdict of ordinary observation by the "man in the street." For instance, it may well happen that a green surface which, when measured in this way, is found to have a brightness of 0.001 eq. ft.c. appears far brighter than a red surface which also measures 0.001 eq. ft.c. In fact, it will be obvious that this must be so on account of our old friend the Purkinje effect, for the insertion of the low transmission neutral filter, by bringing the brightness down to a low figure, gives the green a great advantage over the red.

It is clearly of no use for the photometrist to say: "These surfaces give the same reading on the photometer and, therefore, they must be equally bright." The man in the street will simply reply: "That is nonsense, because anyone can see for himself that the green surface is very much brighter than the red, and no one who isn't blind would say differently."

The only thing to be done is to accept the facts as they are and to agree to define equal brightnesses as those that appear equal to the average observer. This means, of course, that if we define 0.001 eq. ft.c. as one-thousandth of 1 eq. ft.c. for white surfaces, then for a green surface 0.001 eq. ft.c. is *less* than one-thousandth (perhaps about half a thousandth†) of 1 eq. ft.c., while for red it is *greater* (perhaps about one or two hundredths†). Further since the Purkinje effect does not occur suddenly at

* This is done by multiplying the reading by the conversion factor stated (see B.S.S. for Portable Photometers, No. 230 1925, Clause 5).

† The actual values naturally depend to some extent upon the particular parts of the green and red portions of the spectrum which we are considering.

one particular brightness level, but gradually increases as the brightness falls from about 0.3 eq. ft.c. to 0.001 eq. ft.c., it is not possible to determine a simple factor for each colour which will apply at all levels of brightness that are practically important.

All that we can do, then, is to say that the scale of brightness shall be defined by means of white surfaces*, and that the brightness of all other surfaces shall be determined by visual comparison with a white surface. Thus, if a green surface appears to the average observer to be, as nearly as he can judge, neither darker nor lighter than a white surface having a brightness of 0.05 eq. ft.c., then the brightness of the green surface is also 0.05 eq. ft.c., and the same applies to a red surface or one of any colour whatsoever.

Sometimes the brightness defined in the way just described is called "apparent brightness," to show that it has not been measured by a simple mechanical reduction (e.g., with a neutral filter or a sector disc) of a much higher brightness, one which is above the limit at which the Purkinje effect begins, and which can therefore be measured in the usual way.

There are still one or two snags which have to be avoided when making measurements of apparent brightness. These, again, are due to the peculiar behaviour of the eye and the way in which it is constructed. When we are in the dark or near-dark, the pupils of our eyes are fully dilated so that their intake of light is at its maximum. This condition should be reproduced when brightnesses are being measured, and therefore we must be careful that no eyepiece in the measuring instrument acts as an artificial pupil cutting down the amount of light which enters the observer's eye. The maximum diameter of the natural pupil is about 8 mm., so that no artificial pupil should have a diameter of less than, say, 9 or 10 mm.

The other snag is less obvious. The sensitive surface in our eye, the retina, upon which is focused the image of any scene we are looking at, has near its centre a tiny supersensitive portion called the *fovea*, and when we gaze straight at a small object we automatically turn our eyes so that the image of this object falls on the *fovea*. Now at the *fovea* the Purkinje effect either does not occur at all or only to a very small extent, and therefore if we are looking at two small surfaces side by side, one green, say, and one white, we shall not get the same result as if the surfaces were large. For this reason it has been specified that in making measurements of apparent brightness the surfaces shall subtend an angle of at least 10 deg. at the observer's eye. This corresponds to a disc of 6 in. diameter looked at from a distance of just under 3 ft.

* For greater precision, the particular "white" adopted has been defined as light of colour temperature 2360 deg. K. In effect, this means a colourless surface, e.g., magnesium oxide, illuminated by a tungsten filament vacuum lamp.

I.E.S. Centre Activities

In addition to the events noticed elsewhere, there have been a number of successful meetings held by I.E.S. Centres.

Dr. J. H. Shaxby, who had lectured on "Colour and the Eye" to the Manchester Centre, on December 12, 1946, repeated the address at a meeting organised by the Cardiff Centre, in Newport, on March 6, which proved very successful.

At Nottingham, on January 3, the Centre organised a series of three papers of 15 minutes each on "Lighting as applied to Churches" (C. S. Caunt), "Lighting as applied to Hospitals" (P. M. Moore), and "Lighting as applied to Schools" (N. C. Slater)—a form of meeting in which the Nottingham Centre seems to excel, and which led to a good discussion. On March 7, Councillor C. S. Caunt stepped into the breach caused by inability of Dr. Ward to attend, owing to travelling difficulties, and gave members an account of his course on Illumination Design, given at the College of Art.

Under the title "Dirt Cost Money," Mr. C. F. Hurd, on February 3, gave the Sheffield Centre an instructive talk on maintenance—terminating by a practical example of a consumer paying £100 out of £200 for light which he was not receiving, owing to absorption by dirt in various forms.

Huddersfield, on March 4, were treated to a lecture on "Light by Fluorescence," by Dr. G. C. Stephens, and on April 1, to a lecture on "Glass in the Service of Light," by Dr. A. J. Holland.

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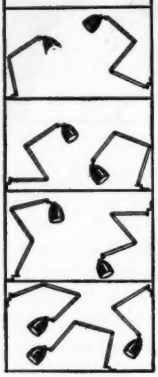

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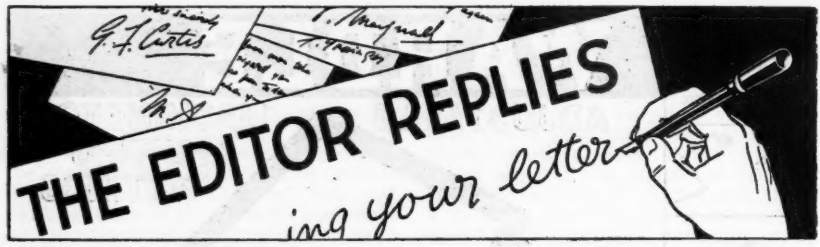


I have been asked when the awaited **Textbook on Illuminating Engineering,** which Dr. Walsh has in preparation, is likely to make its appearance. I believe that Dr. Walsh completed his task quite a considerable time ago, but, as usual in present circumstances, there has been some difficulty and delay in regard to printing. It is satisfactory to learn, however, that good progress is now being made and that copies should be available within the next few months—in which case it appears likely that it will see earlier publication than the corresponding volume for which the I.E.S. in America is responsible, no doubt a more formidable effort.

I have had some further suggestions in regard to the proposed term to signify **"Lumens per square foot."** I find some agreement with the view that the mere use of initial letters does not meet the problem. On the other hand some objection is taken to the **"lume"** proposed by Mr. R. R. Holmes, for example, that it is too easily confused with "lumen." Therefore, it is suggested let us go further and adopt the term **"lu"**—"la" being Lumen/men, i.e., the division of the flux of light by men over some assigned area. (I forestall the irreverent comment, "What then is meant by Lulu?")

It is now some time since I was asked to mention a **church equipped with fluorescent lighting** which could be inspected by anyone interested. Fate—or rather the G.E.C.—has now furnished an example, the lighting of St. Paul's Church, Harringay (London), illustrated on the opposite page. Some doubt has been expressed in regard to the desirability of using fluorescent lamps for the general lighting of churches, though in this instance the change has evidently been of practical benefit.

SITUATION VACANT

JUNIOR ENGINEER required for development work on Fluorescent Lamp Auxiliaries by a firm in North London. Experience in photometry an advantage. Degree in engineering or H.N.C. standard preferred. Salary according to qualifications and experience.—Write Box No. 762, c/o. "Light and Lighting," 32, Victoria-street, London, S.W.1.

SITUATION WANTED

TECHNICAL ENGINEER, 41, A.I.E.E., Corporate Member I.E.S., desires progressive position as Sales and Planning Engineer for industrial power, lighting, or space heating systems. Twenty years' established connection over wide area of Midlands with electricity supply undertakings, large industrial concerns, and the electrical trade generally. Agencies also considered.—Reply in confidence to: BM/KAY11, London, W.C.1.

Fluorescent Lighting in a Church

St. Paul's Church, Harringay, illustrated below, has been entirely re-lit with 5 ft. 80w. Osram warm-white fluorescent lamps. This is believed to be the first installation of its kind. This church, which was built about 56 years ago, is in the style of the thirteenth century. The aisles are narrow and the roof is very high. Some daylight, not usually sufficient for reading, is admitted through windows along the aisles and above the altar.

The old system of artificial lighting was by 350w. tungsten lamps in pendant fittings, yielding less than 1 ft.c. The aisles were seldom occupied as it was impossible to read in the dim light. Power consumption was heavy and the fittings collected dust rapidly.

The new system incorporates 14 double-tube fittings, and in all a total of 34 fluorescent lamps. There are five two-tube mountings on each side of the nave, which are visible from most parts of the church, but there is no glare and soft shadow. The average illumination is about 3 ft.c., and it is possible to read with comfort in any part of the nave or aisles. Special concealed lighting is afforded for the altar and war memorial at the back of the font. The consumption on the old system was 4,800 watts. Now, although only 15 per cent. of this wattage is used, the illumination has been increased by 300 per cent.

The lighting consultant was Mr. F. C. Orchard, Chief Electrical Engineer of the Hornsey Electricity Department. The wiring contractors were Sandilands, Ltd., and the lighting fittings were supplied by Linealux, Ltd.

I.E.S. Nottingham Centre: New Honorary Secretary

As we go to press we learn that Mr. C. S. Caunt will cease to be Hon. Secretary of the I.E.S. Nottingham Centre, from May 9 onwards. His place, on retirement, will be taken by Mr. A. Hacking (32, St. Leonard's Drive, Wollaton, Notts). All I.E.S. members will join in appreciating the very valuable work Mr. Caunt has done for the Society in Nottingham during the past eight years.

Wanted: "Photometry" by Dr. J. W. T. Walsh

A member of the staff of the Standards Laboratory of South Africa is urgently in need of the above book. Has any reader a copy, of which he would be willing to dispose?

ERRATUM.

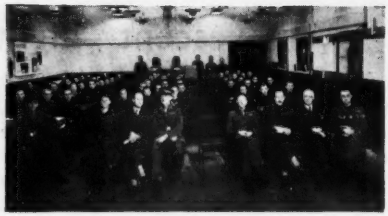
Our attention has been drawn to an evident error in the note on Heat-absorbing Glass, which appeared in our March issue (p. viii). The figures for thicknesses of glass mentioned in the second paragraph were incorrectly given as being in inches, instead of in *millimetres*.

Fluorescent lighting in St. Paul's Church, Harringay.

Lighting Education for the Forces

For some time special courses for the Army have been held at the E.L.M.A. Lighting Service Bureau. The illustrations relate to one of the most recent, on March 21, when Col. F. P. Roe, Command Education Officer for the London District, and many other officers attended—not so much to learn about lighting as to see how the men were being taught. It is believed that the example set by the Bureau might well be followed in connection with other trades and industries.

A notice circulated by Captain A. J. Ketley (Captain, R.A.E.C., No. 1 Education Officer) commended this practical method of education, and it was his desire that an opportunity of witnessing it in action should be afforded to all officers interested.



A view of the audience with Mr. E. B. Sawyer, manager of the Bureau, and education officers and others interested in the foreground.

The Trend of Street Lighting

A paper on the above subject is to be read by Mr. N. Boydell, M.I.E.E., at a conference arranged by the A.P.L.E. in connection with the Public Works, Roads and Transport Congress, to take place at Olympia during July 21-26. The paper is to be read at 3 p.m. on July 22. Mr. W. N. C. Clinch, President of the A.P.L.E., will take the Chair.

A demonstration during the lighting course for Army personnel, of some of the shorter lengths of fluorescent lamps.

Lighting for Air Liner Construction

The accompanying photograph shows a view of one section of the Chadderton factory of Messrs. A. V. Roe and Co., whence have come the famous Lancaster, York, and now Tudor aircraft—the last-named peace-time liners.

For all this work similar lighting conditions were required, and the lighting was planned by Metrovick illuminating engineers in conjunction with Benjamin Electric, Ltd., and Messrs. W. H. Smith and Co. Most bays use 400 w. standard mercury discharge lamps, yielding 10 lumens per sq. ft., whilst in the large machine and bench assembly shops as much as 15-20 lumens per sq. ft. are provided. Absence of glare is regarded as a vital consideration. A special problem is the provision of illumination inside the fuselage, and for this purpose special handlamps fed by transformers, avoiding all danger of shock, have been designed.

A view of a section of the Chadderton factory of Messrs. A. V. Roe & Co. Ltd., whence many famous types of aircraft have emanated.